Critical Reynolds number for global instability of channel flow in subcritical scenario

TAKAHIRO ISHIDA, TAKAHIRO TSUKAHARA, Department of Mechanical Engineering, Tokyo University of Science — We perform direct numerical simulations for the transitional pressure-driven channel flow and investigate the critical Reynolds number for global instability (ReG). In the channel flow, the critical Reynolds number relevant to local (infinitesimal) instability (ReL) is known as 5772, which is based on the channel half width (h/2) and the channel centerline velocity in laminar flow, by the linear stability theory. However, the understanding of ReG is still unresolved because it is inherently non-linear. In this study, temporal progress of a turbulent spot that grows from finite disturbance in the laminar flow is analyzed. We use the small and the large computational boxes for identifying the lower critical number, which are \( L_x^* \cdot L_y^* \cdot L_z^* = 6.4h^* \cdot 3.2h \) and \( 102.4h^* \cdot 51.2h \), respectively. For the small box, we determine ReG|S is 1400. The flow regime observed in the small box is only either laminar flow or fully-developed turbulence. As for the large box, we obtain ReG|L of 875 because of the emergence of the transitional structure named “turbulent stripe,” or a coexistence of oblique turbulent and laminar region. Because the spatial size of turbulent stripe is much larger than the small box, ReG|S indicates the critical Reynolds number for the flow without large-scale intermittency. Therefore, we found that the existence of turbulent stripe caught in large box would decrease the ReG value compared to those proposed by previous studies.

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